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Abstract

CONSTRUCTIVE USES OF NUCLEAR EXPLOSIVES--PROJECT PLOWSHARE

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The exploration of possible constructive uses of nuclear explosives, initiated in the United States by the Atomic Energy Commission in 1957, has continued and substantial progress has resulted. Major advances have been achieved in the development of much cleaner explosives. These will extend the range of possible use and lead to lower cost systems because the investment in expensive fissionable material is reduced. Several nuclear experiments have been carried out which provide an improved technological base from which to assess both the feasibility and cost of desired projects.

The effect of the additional knowledge has been to increase the confidence in the feasibility and economic advantage of nuclear excavation, certain underground mining applications, increasing production of gas fields, and isotope production for research.

Further development of nuclear explosives has resulted in impressive reductions in fallout to be expected from excavation projects. The land areas that would have to be temporarily excluded have been reduced to those that must be controlled to avoid hazard from throw-out of material, dust, air blast and ground shock.

Nuclear cratering experiments at 420 tons in basalt and 100 kilotons in desert alluvium (a lightly cemented sand and gravel), as well as expanded supplementary chemical-explosives program, have been conducted. They provided confirmation of scaling laws and important new information on the release and distribution of radioactivities. The formation of the early cloud, base surge, and some other effects, were different in the two media and affected, to a marked degree, the distribution of fallout. Documentation of the partial distribution of specific isotopes, such as Cs-137, Sr-90, and I-131, and the

gross radiation field, were accomplished on both events. In cases in which active grazing land may be nearby, I-131, a fission product, has been identified as an isotope requiring specific attention and special control during the grazing season.

The costs and feasibility of the possible construction of a sea-level canal across the American Isthmus have been reassessed in terms of all new information. A detailed engineering analysis was first made in 1960. Because of the improvement in explosives technology and reduction of radioactivity, the project appears in the new study more feasible and less costly than in the 1960 study. The conceptual canal would have a width of 1000 feet and a minimum depth of 60 feet. The total cost to produce such a canal is now estimated to be about $500 000 000. Other smaller promising projects are under active study and are described in the paper.

To further develop the technology, additional cratering experiments are planned. These include rows of charges to provide ditches in hard rock and larger-yield single shots in various media of interest. Some progress is being made in a continuing major theoretical effort to develop calculational models of cratering phenomena.

Contained nuclear explosions have been fired in four media--tuff, granite, desert alluvium, and salt. The explosions have been carried out for a variety of purposes. The yields have extended from a fraction of a kiloton to hundreds of kilotons. The aggregate experience, coupled with theory, has led to a reasonable understanding of many of the basic processes involved. As a consequence of this experience, the use of nuclear explosives for breaking up of competent rock in certain mining applications appears both technically and economically attractive. Cases in point are the mining of molybdenum and possibly low-grade copper deposits. Knowledge of fracture zones and cavity formation has also led to favorable consideration of techniques that may increase production from petroleum gas wells.

The techniques of containment and quick recovery of isotopes from an explosion offer the potential, through use of suitable designed explosive devices, of obtaining, and possibly recovering through mining, new species of isotopes.

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CHEMONUCLEAR PROCESSES

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A chemonuclear reactor is defined as a nuclear reactor that makes direct use of a significant fraction of the energy of fission, either as the kinetic energy of the fission fragments, or as the kinetic energy of neutrons, betas and gammas associated with fission, to break chemical bonds and form a chemical product. A chemonuclear plant would consist of (1) a nuclear island which contains the equipment in which the chemical bonds are broken and the desired products are formed; (2) a radiochemical island in which the product and side products, if any, are separated from the primary reactant fluid and radioactivity is removed from the product; (3) a conventional chemical island which contains equipment for handling the non-contaminated inputs and outputs of the plant; and (4) a turbine island to generate by-product electricity, if the plant is a dual-purpose one.

Cost analyses have been made of nine different chemical products, and data generated to indicate the economic potential of the processes. The present status of chemonuclear research is illustrated by a review of the chemistry and technology of two processes -- the fixation of nitrogen and the production of hydrazine.

Gamma-ray capsule data, fission-fragment capsule data, and fission-fragment loop data are presented for the yield and steady-state concentration of NO_2 in the radiolysis of N_2/O_2 mixtures at a variety of temperatures and pressures, and also for the yield and steady-state concentration of N_2H_4 in the radiolysis of liquid NH_3.

An analysis has been made of the accuracy of the fission-fragment data obtained thus far. Problems of fission-fragment dosimetry and energy-deposition efficiency have been investigated. Fission-fragment sources for research and for potential fission-fragment reactor fuels have been studied, as have characteristics (including radiation damage and chemical corrosion) of U-bearing glass fibers, UO_2 particles and experimental fission-fragment sources using U/Al foil, U/Pd foil and UO_2 particles. Foil fuel elements for fixed-fuel gaseous chemonuclear reactors have been described. Experience with fine particulate UO_2/liquid-NH_3 slurries has been obtained.

Descriptions are given of the operating RPI gas loop, the operating AGN hydrazine loop, and the proposed BNL gas loop.